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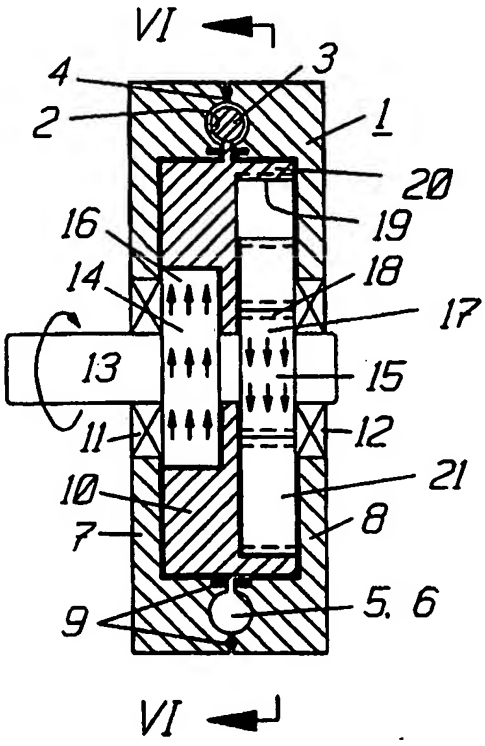
(54) Title: PENDULUM PISTON MOTOR

(57) Abstract

A hydraulically or pneumatically actuated pendulum piston motor or ring (toroid) piston motor comprising a cylinder housing (1) having a cylinder (toroid) race (2) therein, in which a pendulum piston (3) is swingable in two opposite swing directions, and in which the cylinder race (2), at a place thereof, is divided by a piston chamber wall (4) which defines a piston chamber (5 and 6) on each side of the piston (3), and in which the pendulum piston (3), via a fly mass (10), is connected to a central, output shaft (13) and is arranged to operate over an actuation angle in each swing direction of 340-355°. The pendulum piston motor is formed with two free wheel couplings (14, 15) acting in opposite directions in relation to each other, and with means (17-21) for inverting the direction of rotation of the output shaft (13) during one swing direction of pendulum piston (3).



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PENDULUM PISTON MOTOR

The present invention relates to a hydraulically or pneumatically actuateable pendulum piston motor or toroid piston motor, whereby is meant a motor having a piston which is reciprocatable in a circular cylindric (toroid) chamber and which has a central output shaft, and in which the piston is arranged to perform a reciprocating work under the action of a hydraulic pressure medium like oil, water or another liquid, or a pneumatic pressure medium like air, another gas, steam, combustion gases etc., whereby the pressure medium is alternatingly introduced into opposite pressure chambers of the motor, so that the piston exerts a reciprocating pendulum movement.

Pendulum piston motors or ring piston (toroid type) motors of the said type are known for instance from DE-O-1.750.601 or GB-P-2.239.053. In the apparatus of said two patent publication there is obtained a reciprocating (oscillating) movement of the output shaft, which movement is suited for certain applications. It may, however, be difficult to make use of such reciprocating movement as a drive means for applications where a constant driving in one and the same direction is necessary, and therefore, the said motors are not suited as drive motors for rotary machines, for vehicles and other apparatus in which there is desired a drive movement with a constant direction of rotation and a constant of nearly constant drive force.

A further rotary actuator is known from GB-A-2.312.248. Said rotary actuator is formed with a piston assembly moving in a toroidal pressure chamber to provide an angular motion of a drive shaft over a flange plate connected to said drive shaft over a ratchet type clutch. The actuator is adapted to transform pressure signals into angular motion, and it operates from pressure signals.

None of the known prior art apparatus is capable of providing a uniform rotation in one single direction of an output shaft using a reciprocating pendulum piston motor.

The primary object of the invention therefore has been to solve the problem of providing a pendulum piston motor of the above mentioned type, in which the output shaft rotates in one and the same direction and which has controllable, constant or nearly constant drive force, notwithstanding the fact that the piston performs a reciprocating pendulum movement.

A motor of the said type presents several advantages, namely that it can be made with small dimensions and as a lightweight unit, the drive force

of the motor can very easily be adapted to the actual needs, it can be driven with many different types of hydraulic or pneumatic pressure medium, it provides a very high efficiency in relation to its weight, it provides a practically constant drive force over the entire stroke of operation, it can be driven with a pressure medium which does not give any exhaust gases at all or any other unfavourable environmental effects, it can be manufactured to substantially reduced costs considering the motor effect, than is possible for conventional OTTO engines, DIESEL engines, WANKEL engines or other types of internal combustion engines. A further great advantage with the motor in question is that the motor, for each single operation cycle, develops a work which is far greater than the work which can be developed per operation cycle by a conventional internal combustion engine, namely 6-10 times greater that the work which is developed per operation cycle by a conventional internal combustion engine or 4-stroke type, or at least 4 times greater that the work which can be developed by an internal combustion engine of 2-stroke type.

In the accompanying figure 1 there is shown the known principle for an internal combustion engine having a reciprocatable piston and a rotary crank shaft comprising an output shaft. It is known that the force from such an engine is developed according to a type of GAUSS curve, whereby the force is slowly increasing from 0° for a 2-stroke engine, or from 360° for a 4-stroke engine, over a maximum force for the output shaft is obtained at about 90° and 450°, respectively, whereupon the force is slowly decreasing to a zero force at, or very closely following 180° and 540°, respectively.

A pendulum piston motor can be designed so as to give full force during almost the entire pendulum movement in each of the two opposite directions. The restriction of the force output is provided by the means for supply of the hydraulic or pneumatic pressure medium and for inverting the supply direction thereof, which means can be restricted to 10-20° of a full rotational turn thereof. A pendulum motor is diagrammatically illustrated in figure 2.

In figure 3 the power output of a pendulum piston motor is marked with phantom lines, and the power output of a 4-stroke engine, similar to a GAUSS curve, is marked with the double shadow part at the position between 360 and 540°, that is at two full turns of the engine. In figure 4 there is correspondingly shown the power output for a pendulum piston motor and for a 2-stroke internal combustion engine, respectively, at two full turns of the engine. It is obvious that the average work exterted by a 4-stroke internal

combustion engine exerts is only about 1/8 of the work which is exterted by a pendulum piston motor during the same time of operation, and that the average work exterted by a 2-stroke internal combustion engine is only about 1/4 of the work that a pendulum piston motor exerts during a time corresponding to two turns of the output shaft.

As mentioned above an ordinary pendulum piston motor provides a reciprocating or oscillating (swing) movement of the output shaft, which movement can not, without involving special measurements, be utilized as a drive force in case a drive force having a constant direction of rotation is desired.

According to the invention the pendulum piston motor therefore is formed with means for inverting the direction of rotation of the output shaft either during the clockwise movement or during the counter clockwise movement of the pendulum piston. This can be done in that the motor is formed with a planetary gear which inverts the direction of rotation at one of the movement phases of the pendulum piston. For making it possible to receive a power output at both directions of rotation the pendulum motor also comprises two free wheel couplings, a first free wheel coupling for the "forward" movement and a second free wheel coupling for the "rearward" movement. The two free wheel couplings are mounted in opposite operation directions in relation to each other, so as to allow driving and free wheel running in opposite directions of rotation, whereby the output shaft is driven with a constant direction of rotation. The planetary gear preferably has a gear change of 1:1, but for providing special effects it is also possible to make use of any other gear change for the planetary gear, whereby a periodical fluctuation of the drive movement of the output shaft can be obtained.

The two free wheel couplings foresee a rotary movement of the output shaft even for a very little movement of the pendulum piston, and depending on the two counter acting free wheel couplings, including the planetary gear, there is obtained a stepless reversing of rotary movement of the output shaft.

Depending on the interaction of the two free wheel couplings and the planetary gear there is automatically obtained a free wheel function of the output shaft, meaning that there is obtained an idle running whenever an apparatus which is drivingly connected to the output shaft is running faster than said drive motor. When the drive shaft of said pendulum piston motor is still standing said apparatus which is drivingly connected thereto can only

move corresponding to a clockwise direction of the pendulum piston motor. Therefore the apparatus of the invention can not involve any braking moment in the apparatus.

Now the invention is to be described more in detail with reference to the accompanying drawings. In the drawings figure 1, as mentioned above, diagramatically shows the operation of an internal combustion engine of OTTO type or DIESEL type. Figure 2 diagrammatically shows the operation of a pendulum piston motor. Figure 3 is a curve showing the work which is exerted both by a pendulum piston motor according to the invention (phantom line area), and by a 4-stroke internal combustion engine (double phantom area), and figure 4 correspondingly shows the work exerted by a pendulum piston motor and by a 2-stroke internal combustion engine. Figure 5 shows a cross section view through a simple type of pendulum piston motor according to the invention, as seen in the plane of the output shaft thereof, and figure 6 shows a cross section view following line VI-VI of figure 5. Figure 7 diagrammatically shows the operation of a pendulum piston motor according to the invention, as seen perpendicularly to the output shaft. Figure 8 shows, in the same way as in figure 5, a combined pendulum piston motor. Figure 9 shows, more in detail, an example of a control apparatus for alternating the pressure medium supply to the two piston chambers of the pendulum motor, and figure 10 shows, in detail, the position of the control apparatus after readjustment of said control apparatus and for introduction of pressure medium in the left piston chamber as shown in the drawing.

The pendulum piston motor according to the invention, shown in figures 5-7, generally comprises a cylinder housing 1 having a ring shaped (toroid) cylinder race 2, in which a pendulum piston 3 is arranged to swing reciprocatingly between the two sides of a piston chamber wall 4 which is formed with means for supply of pressure medium to the piston chambers 5 and 6 appearing at opposite sides of the pendulum piston 3.

The cylinder housing 1 comprises two house halves 7 and 8 which are split perpendicularly to the output shaft and which, as known in the art, are sealed 9 both outwards and inwards in relation to the cylinder race 2 so as to form two opposite piston chambers 5 and 6 which are sealed in relation to each other. The pendulum piston 3 is formed as a projecting part having an inner fly mass 10 with a piston neck 10a which keeps the piston 3 in place in the cylinder race 2. The fly mass 10 is beared in the centre of the cylinder

housing by means of bearings 11, 12 on each side of the housing and under co-operation of a shaft of rotation 13 and two counter-acting free wheel couplings 14 and 15, respectively. One 14 of the free wheel couplings provides a drive transmittance in one direction, marked with arrows 16 and a free wheel function in the opposite direction of rotation, and the other free wheel coupling 15 provides a drive transmittance in the opposite direction as compared with the free wheel coupling 14, marked with the arrows 17. In the two opposite directions of the free wheel couplings there is, as known per se, obtained a substantially resistance-free movement of rotation. The right hand free wheel coupling 15 shown in figure 5 is enclosed in the inner sun wheel 18 of a planetary gear, the outer sun wheel 19 of which is fixed mounted in an axially projecting collar 20 of the fly mass 10. Said outer sun wheel 19 is drive connected to the inner sun wheel 18 over three, or more, planetary wheels 21. For providing an even and uniform movement in both directions of rotation the planetary gear ought to have a gear change between the planetary wheels 21 and the inner sun wheel of 1:1. For special use, however, it is possible to make use or another gear change, so that the piston moves quicker, or more slowly, in one of the piston movement directions than in the opposite piston movement direction.

The purpose of the planetary gear is to invert the direction of rotation during one of the piston movements so that the output shaft 13 is always driven in the same direction of rotation.

The means for supply of hydraulic or pneumatic pressure medium are connected to the piston chamber wall 4. Said pressure supply means can be formed in various ways, but they ought to be arranged and controlled by the geometry of movement of the pendulum piston, so that the pressure medium supply is changed between the two piston chambers 5 and 6 at a certain desired position of the piston 3. For obtaining an optimum work said change of pressure supply can be made when the piston has reached as far as to the rear piston chamber wall, or is located very close to said wall. In figure 7 is indicated that the controlling of the pressure medium supply can be made by means of a rotatable valve 22 the operation of which can be controlled by the movement of the piston 3, so that the pressure medium supply is changed between the two chambers 5 and 6. The operation and controlling of the valve can be made mechanically, electronically, hydraulically or by any other means in correspondence to the movements of the piston 3 in the cylinder race 2.

In figure 7 is shown that the pressure medium is supplied to piston chamber 5, and this makes the piston 3 rotate in the clockwise direction. For draining the hydraulic or pneumatic pressure medium from the non-operative piston chamber, in figure 7 chamber 6, the apparatus is formed any type of evacuation means of priorly known type, not shown in the drawings, for instance a passageway having a non-return valve leading out to the ambient and provided in the piston chamber wall 4. Such a non-return valve becomes operative only when the opposite piston chamber is under pressure. In figure 7 there is indicated that the piston chamber 5 providing a clockwise operation receives pressure medium over a passageway 24 in the piston chamber wall, whereas the opposite piston chamber 6 is drained of pressure medium.

The pressure supply can be varied as desired and to provide the torque and the rotational speed which is desired at the output shaft 13. The apparatus can be formed with a choke valve connected to the pressure medium supply means for providing a soft starting and a controlled speed and a controlled torque.

A pendulum piston motor of the above described type can be used for many different purposes, for instance as a drive motor for a vehicle or a machine of any type, even without use of a gear box since the force and the speed at the output shaft 13 can be varied from zero to maximum only by controlling the pressure of the drive pressure medium. There is also no need for a sliding clutch for providing a soft starting since this can easily be accomplished by means of a choke valve which controls the pressure and the flow of fluid to the cylinder chambers from zero to maximum. A free wheel running of the vehicle is obtained by the action of the two free wheel couplings 14 and 15. A rear driving function can be obtained by using a simple mechanical reverse gear.

In figures 9 and 10 there is shown an apparatus in which the changing of pressure medium supply between the two pressure chambers 5 and 6 is made by the piston 3 itself. In this case the pressure change piston is formed as a rotatable slide 25 which is formed with actuation arms 26 which project downwards and are provided on opposite sides of the piston chamber wall 4. The actuation arms 26 are pushed by the piston 3 when reaching the end of its operative stroke, whereby the slide valve is switched over from clockwise actuation or counter clockwise actuation of the piston, and vice versa. The pressure medium is supplied through a central bore 27 and through

passageways 28, 29 and openings 30 and 31 in the valve slide 25 and from there through further passageways into one of the piston chambers 5 and 6. In figure 9 the valve slide 25 is shown in a neutral position, in which position there is no supply of pressure medium. In figure 10 is shown that the piston 3 has performed a clockwise stroke, has pushed the arms 26 so that the valve slide 25 has taken a position in which pressure medium is introduced in the counter clockwise piston chamber 6 through the passageway 29 and the opening 31 in the valve slide 25, whereby the piston 3 has started its counter clockwise stroke.

Since the planetary gear 17-21 inverts the direction of rotation at the outer sun wheel 19 at one stroke of the motor the output shaft 13 will always rotate in one and the same direction, and this is made possible by the action of the two counter directed free wheel couplings 14 and 15.

The described pendulum piston motor can accomplish an operation over up to 340-350° of the rotational turn, and it is obvious from the diagrammatic curves of figures 3 and 4 that full effect is developed already from the moment that pressure medium is supplied to the pressure chamber 5 for clockwise rotation, and thereby that full effect is developed between about 5° and 355°, and that the supply of pressure medium is thereafter changed to be introduced into pressure chamber 6, in which full effect is developed from about 365° to about 715°, as calculated on a complete working cycle corresponding to two turns of the crank shaft of an internal combustion engine of OTTO or DIESEL type. It is also evident that a 4-stroke engine, during a corresponding time, performs a work the average value of which is only about 1/8 of the work of a pendulum piston motor, and that a 2-stroke engine performs a work corresponding to not more than 1/4 of the work performed by a pendulum motor.

In connection to the changing the supply of pressure medium between the pressure chambers 5 and 6 there appears an insignificant interruption of operation, corresponding to 10-20° of the total work of a full rotational cycle. Said insignificant interruption of work is normally equalized by the fly mass 10 of the pendulum piston motor. The fly mass 10 has to be braked to stop before the pressure fluid in introduced in the opposite pressure chamber and the motor is operated in the opposite direction.

When the valve switches over the supply of pressure medium from one pressure chamber to the other the drain outlet of pressure medium in the

inactive pressure chamber has to be closed before pressure fluid in introduced in said pressure chamber which is thereby made active, which means that the pressure fluid which is entrapped in the inactive pressure chamber, in case of using air as pressure fluid becomes compressed. Depending on said compressing of the entrapped air the piston is braked to stop softly at the end of the stroke. The compressed air can be drained using a pressure controlled valve which opens at a relatively high pressure, for instance 8 bar, whereby said compressed air is introduced in a compressed air tank 34 (see figure 7) and is reused as part of a drive pressure medium at the next drive phase.

It is, however, possible to practically completely eliminate such interruption of operation and to equalize the operation characteristic of the motor by interconnecting two, or more, motors in series with each other on the same output shaft 13, as shown in figure 8. In such case the two or more motors are rotated in relation to each other following the drive shaft 13, that is so that the piston chamber walls 4 of the to or more motors are distributed round the drive shaft, for instance 180° using two interconnected motors, 120° using three interconnected motors, etc. The motors thereby are operated, in relation to each other, so that the interruption of operation, corresponding to about 355-5° are offset to each other. In figure 8 is shown that the means 32, 33 for supply of pressure medium, including the piston chamber walls, are rotated 180° in relation to each other with reference to the output shaft.

REFERENCE NUMERALS

	1	cylinder housing	21	planetary wheel
	2	cylinder race	22	rotatable valve
	3	pendulum piston	23	draining means
5	4	piston chamber wall	24	passageway
	5	cylinder chamber	25	valve slide
	6	cylinder chamber	26	actuation arms
	7	half part of cylinder housing	27	central bore
	8	half part of cylinder housing	28	passageway
10	9	sealing	29	passageway
	10	fly mass	30	bore
	10a	piston neck	31	bore
	11	bearing	32	pressure supply means
	12	bearing	33	pressure supply means
15	13	shaft of rotation	34	pressure chamber
	14	free wheel coupling		
	15	free wheel coupling		
	16	arrow		
	17	arrow		
20	18	inner sun wheel		
	19	outer sun wheel		
	20	collar		

CLAIMS

1. A hydraulically or pneumatically actuated pendulum piston motor or ring (toroid) piston motor comprising a cylinder housing (1) having a cylinder (toroid) race (2) therein, in which a pendulum piston (3) is reciprocatably swingable in two opposite swing directions, and in which the cylinder race (2), at a place thereof, is divided by a piston chamber wall (4) which defines a piston chamber (5 and 6) on each side of the piston (3), and in which the pendulum piston (3), via a fly mass (10), is connected to a central, output shaft (13), and in which the pendulum piston (3) operates over an actuation angle in each swing direction of 340-355°, **characterized** in that the pendulum piston motor is formed with two free wheel couplings (14, 15) acting in opposite directions in relation to each other, and with means (17-21) for inverting the direction of rotation of the output shaft (13) during one swing direction of pendulum piston (3).

2. A pendulum piston motor according to claim 1, **characterized** in that the means for inverting the direction of rotation of the output shaft (13) at one swing direction of the pendulum piston (3) comprises a planetary gear.

3. A pendulum piston motor according to claim 2, **characterized** in that the outer sun wheel of which (19) of the planetary gear is connected to the fly mass (10, 20) of the pendulum piston (3) and in that the inner sun wheel (17) of the planetary gear is connected to the output shaft (13) of the motor via one (15) of the free wheel couplings (14, 15).

4. A pendulum piston motor according to claim 2 or 3, **characterized** in that the planetary gear has a gear change of 1:1 for providing the same speed/power characteristics during planetary gear driving of the pendulum piston (3) as during the free opposite direction of movement of the pendulum piston (3).

5. A pendulum piston motor according to any of the preceding claims, in which the piston is arranged to perform a reciprocating work under the actuation by a hydraulic pressure medium like oil, water or another liquid, or by a pneumatic pressure medium like air, another gas, steam, combustion gases etc., **characterized** in that the motor is formed with a pressure alternating valve (22; 25) adapted to alternatingly feed pressure medium into the opposite pressure chambers (5, 6) of the motor, so that the piston performs a reciprocating pendulum movement.

6. A pendulum piston motor according to claim 5, **characterized** in that the function of the pressure alternating valve (22; 25) is controlled by the movement of the pendulum piston (3) to provide a change of pressure supply when the piston (3) is positioned at, or close to any of the end positions of the piston chamber wall (4).

7. A pendulum piston motor according to claim 5 or 6, **characterized** in that the pressure alternating valve is formed as a rotatable slide (25) which is formed with actuation arms (26) extending into the piston chambers (5, 6) in such a position that they can be acted on by the piston (3) at each direction of movement, thereby providing a readjustment of the function of the pressure alternating valve.

8. A pendulum piston motor according to any of the preceding claims, **characterized** in that it comprises a control valve for controlling the flow of fluid and the pressure of the hydraulic or pneumatic pressure medium to the piston chambers (5, 6) and thereby a controlling of the speed and the torque of the output shaft (13).

9. A pendulum piston motor according to any of the preceding claims, **characterized** in that it is composed of two of more interconnected pendulum piston motor units, which act on one and the same output shaft (13). (Figure 8)

10. A pendulum piston motor according to claim 9, **characterized** in that the piston chamber walls (4) of the two or more interconnected motor units are offset in relation to each other.

AMENDED CLAIMS

[received by the International Bureau on 02 April 1999 (02.04.99);
original claims 1-10 replaced by new claims 1-9. (2 pages)]

1. A hydraulically or pneumatically actuated pendulum piston motor or ring (toroid) piston motor comprising a cylinder housing (1) having a cylinder (toroid) race (2) therein, in which a pendulum piston (3) is reciprocatably swingable in two opposite swing directions, and in which the cylinder race (2), at a place thereof, is divided by a piston chamber wall (4) which defines a piston chamber (5 and 6) on each side of the piston (3), and in which the pendulum piston (3) is connected to a fly mass (10) which is connected to a central, output shaft (13), and in which the pendulum piston (3) operates over an actuation angle in each swing direction of 340-355°, **characterized** in that the pendulum piston motor is formed with two free wheel couplings (14, 15) acting in opposite directions in relation to each other, and with means (17-21) for inverting the direction of rotation of the piston (3) and thereby of the fly mass (10) during one swing direction of pendulum piston (3), and in which one of the free wheel couplings (14) is connected to the fly mass (10) and the output shaft (13), and in which the means for inverting the swing direction of the piston comprises a rotary inverting means which is connected between the fly mass (10) and the second free wheel coupling (15), which, in turn, is connected to the output shaft (13).

2. A pendulum piston motor according to claim 1, **characterized** in that the rotary inverting means which is arranged to invert the direction of rotation of the pendulum piston (3) and the fly mass (10) at one swing direction of the pendulum piston (3) comprises a planetary gear which with the outer sun wheel (19) thereof is connected to the fly mass (10, 20) of the pendulum piston (3), and which with the inner sun wheel (17) thereof is connected to the output shaft (13) of the motor via the second (15) free wheel coupling.

3. A pendulum piston motor according to claim 2, **characterized** in that the planetary gear has a gear change of 1:1 for providing the same speed/power characteristics during planetary gear driving of the pendulum piston (3) as during the free opposite direction of movement of the pendulum piston (3).

4. A pendulum piston motor according to any of the preceding claims, in which the piston is arranged to perform a reciprocating work under the actuation by a hydraulic pressure medium like oil, water or another liquid, or

by a pneumatic pressure medium like air, another gas, steam, combustion gases etc., **characterized** in that the motor is formed with a pressure alternating valve (22; 25) arranged to alternatingly feed pressure medium into the two opposite pressure chambers (5, 6) of the motor, so that the piston performs a reciprocating pendulum movement.

5. A pendulum piston motor according to claim 4, **characterized** in that the function of the pressure alternating valve (22; 25) is controlled by the movement of the pendulum piston (3) to provide a change of pressure supply when the piston (3) is positioned at, or close to any of the end positions of the piston chamber wall (4).

6. A pendulum piston motor according to claim 4 or 5, **characterized** in that the pressure alternating valve is formed as a rotatable slide (25) which is formed with actuation arms (26) extending into the piston chambers (5, 6) in such a position that they can be acted on by the piston (3) at each direction of movement, thereby providing a readjustment of the function of the pressure alternating valve.

7. A pendulum piston motor according to any of the preceding claims, **characterized** in that it comprises a control valve for controlling the flow of fluid and the pressure of the hydraulic or pneumatic pressure medium to the piston chambers (5, 6) and thereby a controlling of the speed and the torque of the output shaft (13).

8. A pendulum piston motor according to any of the preceding claims, **characterized** in that it is composed of two of more interconnected pendulum piston motor units, which act on one and the same output shaft (13). (Figure 8)

9. A pendulum piston motor according to claim 8, **characterized** in that the piston chamber walls (4) of the two or more interconnected motor units are offset in the direction of the output shaft (13) in relation to each other, so that the motor units invert the swinging direction at different angular positions with reference to the output shaft (13).

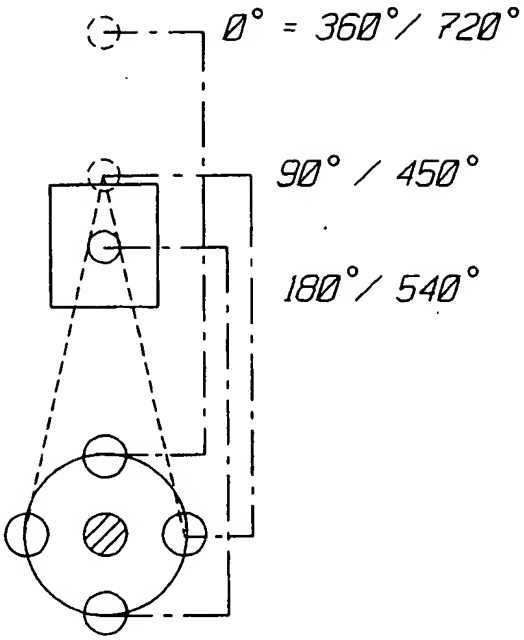

Fig. 1

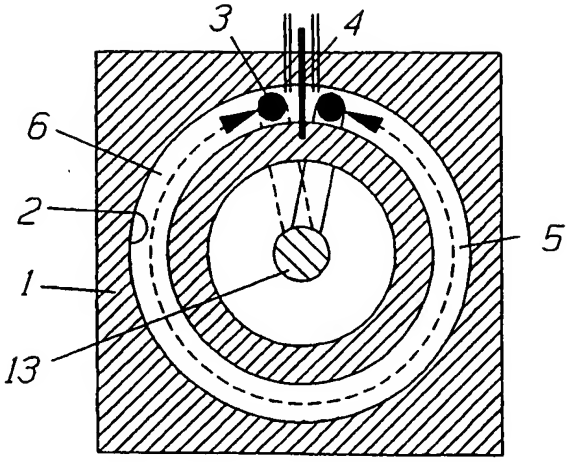

Fig. 2

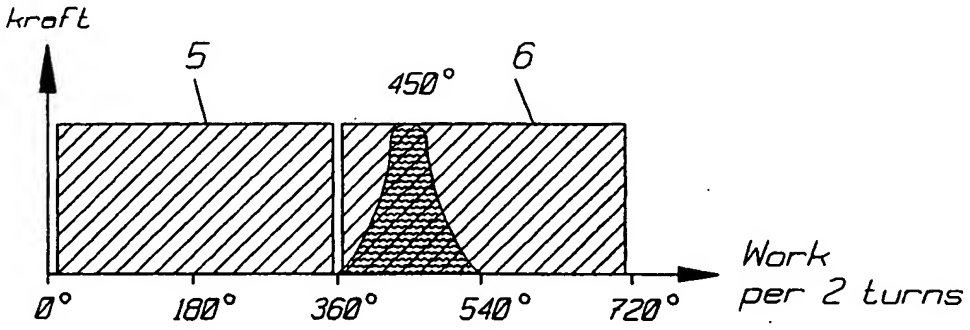

Fig. 3 (4-stroke)

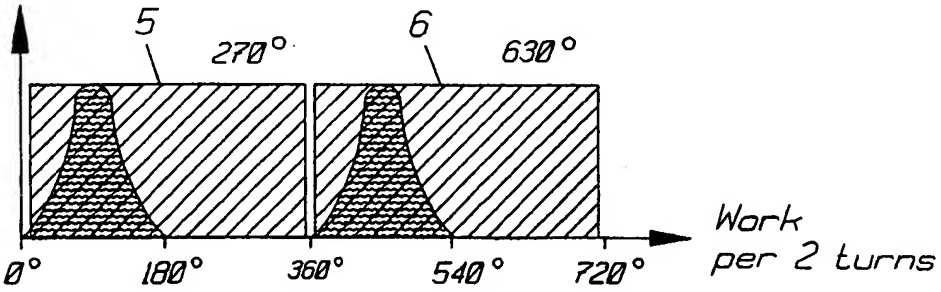

Fig. 4 (2-stroke)

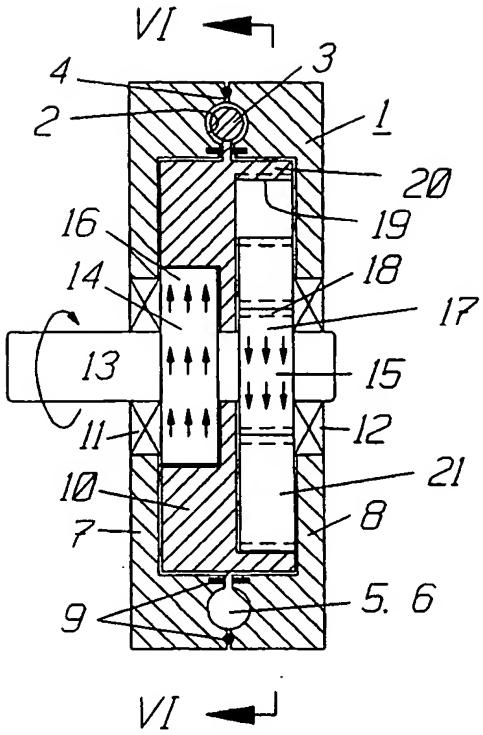

Fig. 5

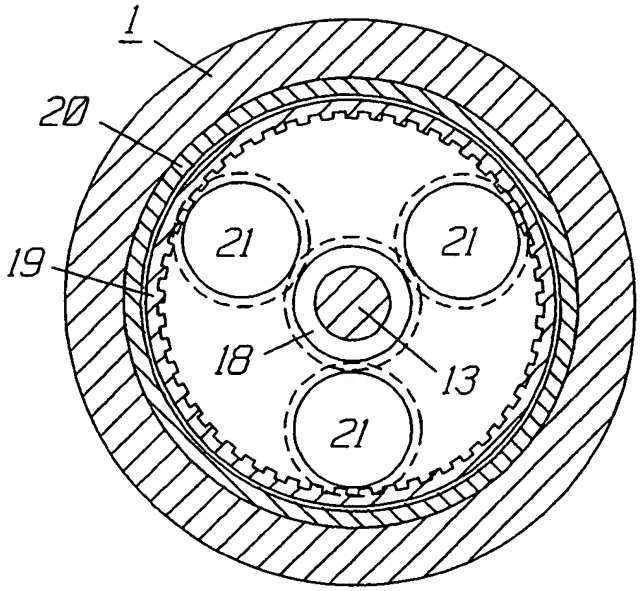

Fig. 6

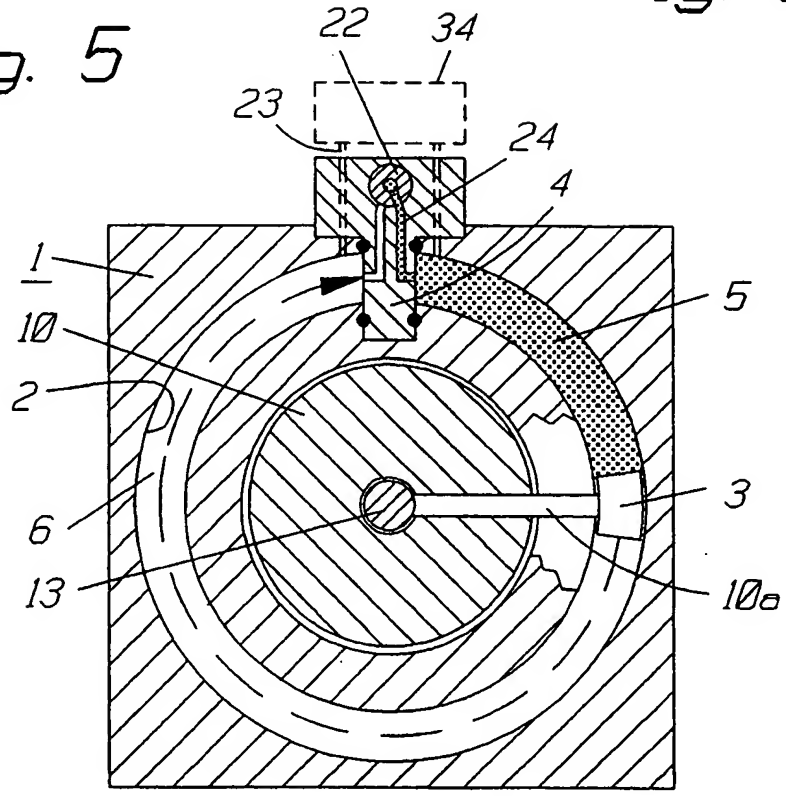

Fig. 7

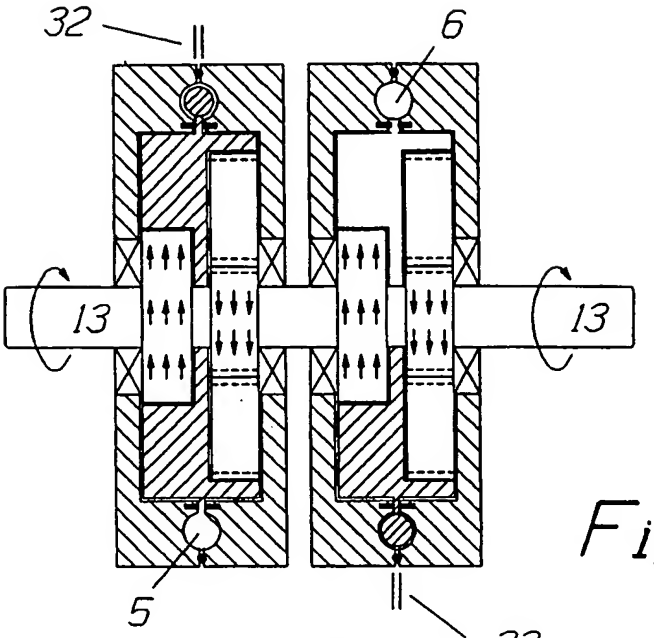

Fig. 8

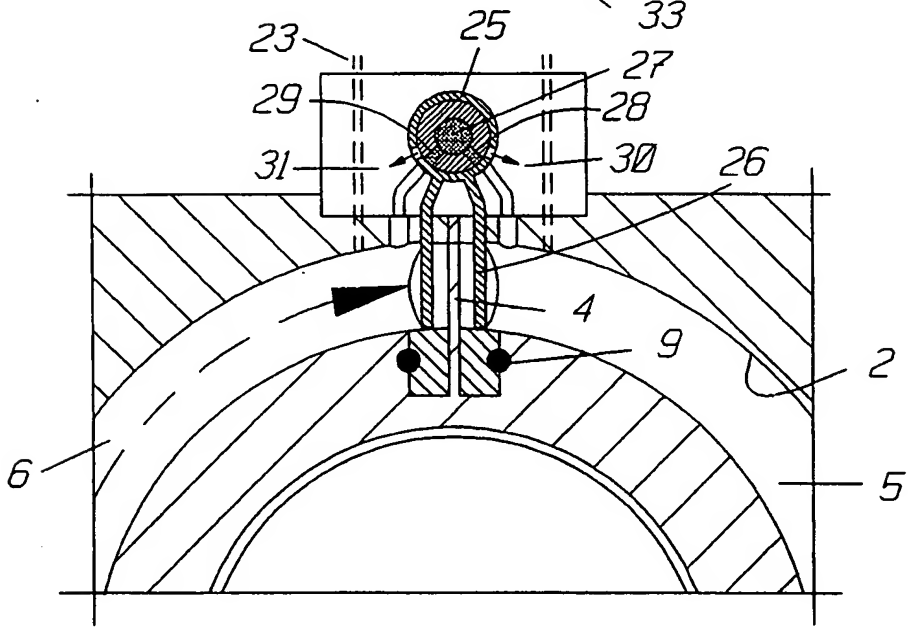

Fig. 9

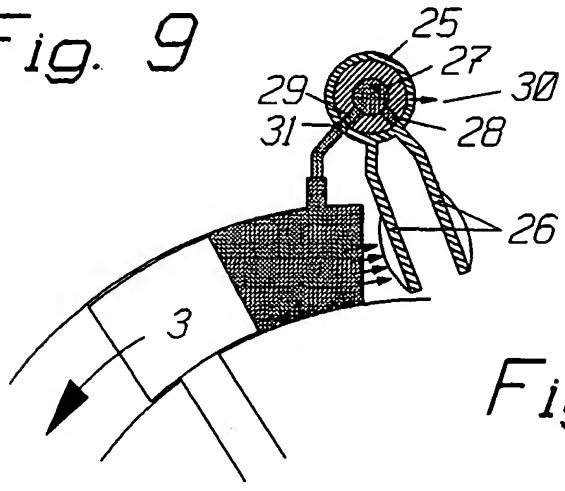

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01511

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F01C 9/00, F04C 9/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F01C, F04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SE 434416 B (ENGINOR AG), 23 July 1984 (23.07.84) --	1-10
X	GB 2312248 A (TERRY THOMAS COOK), 22 October 1997 (22.10.97) --	1-10
X	US 5400754 A (BLANCO PALACIOS ET AL), 28 March 1995 (28.03.95) --	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 November 1998	26-11-1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Lena Nilsson Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/11/98

International application No.
PCT/SE 98/01511

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